

**BROOKHAVEN NATIONAL LABORATORY**

# **OCCUPATIONAL HEALTH**

**AND**

# **SAFETY GUIDE**

**INTERIM**

<b>INSTALLATION OF FLAMMABLE GAS SYSTEMS</b> <b>(Experimental &amp; Temporary Installations)</b>	<i>4.11.0</i>
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## **I. INTRODUCTION**

In support of BNL research and development programs flammable gases have a wide variety of applications. These include detection devices, chemical synthesis, fabrication of metals and glass, and experimental heating systems.

The hazards associated with the nonroutine use of these materials sometimes are not recognized. Explosion and fire is usually the chief concern.

Flammable gas systems, utility in nature, have installation criteria, such as the National Fuel Gas Code (NFPA54, ANSI Z223), which are comprehensive. However, experimental or temporary installations do not have similar installation criteria. This Guide is intended to provide BNL staff information in these latter instances.

## **II. SCOPE**

This Guide covers the general principles recommended for the installation of experimental or temporary flammable gas systems, including flammable compressed gas systems and flammable liquified compressed gas. This Guide does not apply to systems having a total flammable gas content of less than 0.3 cubic meter (ten cubic feet) of flammable gas at one atmosphere. This Guide does not apply to cryogenic flammable gas systems. This guide does not apply to permanent flammable fuel gas systems, essentially utility in nature, for which the National Fuel Gas Code (NFPA54, ANSI 2223) applies.

Where recommendations and procedures are too detailed for inclusion in this Guide, specific references are given to acceptable safety and health standards.

## **III. DEFINITIONS**

**Flammable Gas** is any gas which forms a flammable mixture (explosive mixture) with air at atmospheric pressures.

**A Flammable Gas System** is one in which flammable gas is delivered, stored, and discharged in either the gaseous or liquid state. The system may include stationary or movable containers, pressure regulators, safety relief devices, manifolds, interconnecting pipe, hosing and controls.

**Flammable Gas Volume** is the volume of gas at 1 atmosphere and 20°C (70°F).

**Flammable Liquid** is any liquid having a flash point below 40°C (100°F) and having a vapor pressure not exceeding 275 kPa absolute (40 psia) at 40°C (100°F).

**Outdoors** is any location exterior to a building or structure, and includes locations under a weather shelter or canopy provided this area is not enclosed on more than two sides.

**PSI** - Pounds per square inch gauge pressure.

## 4.11.0

**Separate Building** is a detached building used exclusively to house a flammable gas system.

**Special Room** is a separate enclosed area which is part of or attached to a building and is used exclusively for a flammable gas system.

**Temporary** - A time span of less than 90 (calendar) days.

### IV. RESPONSIBILITIES

A. **Department Chairman/Division Heads** are responsible for ensuring the implementation of this Guide.

B. **Line Supervisors** are responsible for direct implementation of this Guide. Specifically, Line Supervisors are to:

1. review and, where necessary, interpret the contents of this Guide with the user,
2. provide adequate documentation in the form of drawings and specification to the Safety and Environmental Protection (S&EP) Division, sufficient to demonstrate compliance with the provision of this Guide before construction or purchase. Documentation is to be maintained to ensure continued compliance and system status.

C. **Principal Investigators** may have responsibilities that vary with a particular organizational arrangement. With respect to those projects within his/her control, he/she usually assume the responsibilities of the Line Supervisor in implementing this Guide.

D. **User** is to fully conform to the provisions of this Guide in the design and construction of flammable gas systems.

### V. STANDARDS

The design of flammable gas systems, including methods of storage and piping systems, is to comply with the following standards where applicable:

Brookhaven National Laboratory Occupational Safety and Health Guides 1.4.0., "Compressed Gas Cylinders," O.S.H. Guide 1.4.1, "Pressure Systems," O.S.H. 4.12.0, "Classification of Hazardous Locations Containing Flammable Atmosphere."

National Fire Protection Association: NFPA No. 50A, Standard for Gaseous Hydrogen Systems at Consumer Sites; NFPA 54 (ANSI 2223.1), National Fuel Gas Code.

American National Standards Institute: B31.1.0- Power Piping with Addenda, B31.1.0a-; B31.2-, Fuel Gas Piping; B31.3-, Petroleum Refinery Piping.

Compressed Gas Association: P-1, Safe Handling of Compressed Gases; G-5, Hydrogen; G-5.1, Standard for Gaseous Hydrogen at Consumer Plants; S-1.1, Safety Relief Device Standards Cargo and Portable Tanks for Compressed Gases; S-1.3, Safety Relief Device Standards Compressed Gas Storage Containers; S-3, Frangible Disc Safety Device Assay.

### VI. SYSTEM DESIGN

#### A. Containers

1. Flammable gas containers should comply with one of the following:
  - a. Designed, constructed, and tested in accordance with the American Society of Mechanical Engineering (ASME) Boiler and Pressure Vessel Code, Section VIII - Unfired Pressure Vessels. Containers shall be placarded and documentation available.
  - b. Designed, constructed, tested and maintained in accordance with U.S. Department of Transportation (DOT) Specifications and Regulations.

2. Each flammable gas container is to be legibly marked with the name of the gas in accordance with "American Standard Method of Marking Portable Compressed Gas Containers to Identify the Material Contained" (ANSI 248.1-1954). Each manifold gas supply unit is to be legibly marked with the name of the gas.
3. Unless specifically reviewed by the Safety and Environmental Protection Division, each container is to be limited to not more than 10 cubic meters (400 cubic feet) of flammable gas. When sizing a container, it is best to use the smallest size practical (preferably, one month supply or less).
4. Not more than 20 cubic meters (800 cubic feet) of total flammable gas volume in two or more containers should be located in an area of 45 sq. meters (500 sq. feet) or less. Properly arranged exterior storage location should be used for excess storage.
5. Containers are to be provided with substantial noncombustible supports on firm, noncombustible foundations. All containers are to be secured in place to prevent movement, and electrically bonded to the system by means independent of the piping system to prevent static discharge.

### ***B. Safety Relief Devices and Venting***

1. Flammable gas containers are to be equipped with safety relief devices in accordance with the ASME Code or the DOT Specification and Regulations under which the container is fabricated.
2. Safety relief devices and normal venting are to be arranged to discharge upward and unobstructed to the open outside air in such a manner as to prevent any impingement of escaping gas upon the container, adjacent structures or personnel, and not be located so that vented gases are drawn into any building air intake grilles.
3. Safety relief devices or vent piping are to be designed or located so that moisture cannot collect and freeze in a manner which would interfere with proper operation of the device.

### ***C. Shut-off Valves***

1. Manual shut-off valves are to be provided at all points of supply and points of use.
2. Systems over 80 cubic meters (3000 cubic feet) of flammable gas should have shut-off valves in an accessible location outside of the space in which the gas is being used. Where the gas supply is exterior to a building, the shut-off valve should also be exterior.
3. The shut-off valve shall be clearly marked by an indicating sign.

Note: If 4 or less containers supplying the piping system are equipped with individual shut-off valves, a separate valve on the piping manifold discharge is unnecessary.

4. Placement of shut-off valve should consider trapping of gases and potential over-pressures. Additional relief valves should be considered.

### ***D. Piping, Tubing, Hoses and Fittings***

1. Piping, tubing, hoses and fittings are to be suitable for the specific gas service and for the pressures and temperatures involved. Cast iron pipe and fittings are not to be used. Combustible hoses and tubing should be avoided whenever possible, and is not permitted on systems of over 80 cubic meters (3000 cubic feet) gas capacity, nor on system pressure above 15 psig.
2. All piping and tubing should be continuous lengths and not comprised of short sections.
3. Joints in piping and tubing may be made by welding or brazing or by use of flanged, threaded, socket or compression fittings. Gaskets and thread sealants are to be suitable for the specific gas service. Special care should be exercised for supporting compression fitting on each side of a coupling. Compression fittings should be discouraged in areas exposed to vibration.
4. Piping and hoses are to be identified at both the supply and discharge ends with the name of the material being piped. These markings and markings on the pipe run shall be in accordance with BNL OH&S Guide 1.14.0.

## 4. 11. 0

5. Plastic tubing shall only be permitted on low pressure (<5 psi) limited flow rate systems (<1 cfm). Caution shall be exercised to route tubing away from heat sources and sources of ignition. In addition, systems using heavier than air gases shall avoid running in places where gases may collect (i.e., above trenches). It shall be supported at least every 4 ft. It shall be run in areas not subject to mechanical damage.

### E. **Equipment Assembly**

1. Valves, gauges, regulators and other accessories are to be suitable for the specific gas service.
2. Installation of flammable gas systems are to be supervised by personnel familiar with proper practices for their construction and use.
3. Storage containers, piping, hoses, valves, regulating equipment and other accessories are to be readily accessible, and protected against physical damage and tampering.
4. Cabinets or housings containing flammable gas control or operating equipment are to be adequately ventilated.

### F. **Testing**

After installation, all piping, tubing, hoses, and fittings are to be tested and proved gas tight at one and one-half times maximum operating pressure.

### G. **Operating Instructions**

1. For installations which require any operation of equipment by the user, legible instructions are to be maintained at operating locations.
2. Operations should be reviewed annually.
3. Operating instructions shall include the categories: 1) emergency/normal shutdown and 2) unattended operation configurations (if permitted).

## VII. **LOCATION OF FLAMMABLE GAS SYSTEMS**

A. The location of a system is to be in the order of preference as indicated in Table 1.

TABLE 1

Nature of Location	Size of Flammable Gas System		
	Less than 80 cubic meters	80 cubic meters to 420 cubic meters	In excess of 420 cubic meters
Outdoors	First preference	First preference	First preference
In a separate building	Second preference	Second preference	Second preference
In a special room	Third preference	Third preference	Normally not Permitted
Inside buildings not in a special room and exposed to other occupancies	Fourth preference	Normally not permitted	Normally not permitted

B. Guidelines for locating flammable gas systems located outdoors, in separate buildings or in special rooms to an exposure is in accordance with Table 2. The distances in Table 2 (except items 2, 9, and 10) do not apply where protective structures, such as adequate fire walls, are located between the system and the exposure.

TABLE 2 (Minimum Distance in Meters)

Type of Outdoor Exposure		Size of Flammable Gas System		
		10 M <sup>3</sup> to 80 M <sup>3</sup>	80 M <sup>3</sup> to 420 M <sup>3</sup> to	In Excess 420 M <sup>3</sup>
1a.	Fire-resistive construction	0	0	0
1b.	Wood frame structures	3	8	15
1c.	Structure of ordinary non-combustible construction	0	3	8(*)
2a.	Wall Openings (lighter-than-air gases)	Not above any part of a system	3	3
		Above any part of a system	8	8
2b.	Wall Openings (heavier-than-air gases)	Not above any part of a system	8	8
		Above any part of a system	3	3
3.	Flammable liquids above ground	0-3,800 liters	3	8
	In excess of 3,800 liters	3	15	15
4.	Flammable liquids below ground--	0- 1,000 gallons	3	3
		In excess of 1,000 gallons	6	6
		Vent or fill opening of tank	8	8
5.	Flammable gas storage.	0-420 M <sup>3</sup> capacity	3	8
		In excess of 420 M <sup>3</sup> capacity	8	15
6.	Oxygen Storage	340 M <sup>3</sup> or less	6	6
		More than 340 M <sup>3</sup> CF	8	15
7a.	Fast burning solids such as light lumber, excelsior, paper	15	15	15
7b.	Slow burning solids, such as heavy timber	3	8	15
8.	Open flames and other sources of ignition	8	8	8
9.	Air compressor intakes or inlets to ventilating or air-conditioning equipment	15	15	15
10.	Concentration of people (**)	8	8	8
11.	Edge of road	5	5	5

\* But not less than one-half the height of adjacent side wall of the structure.

\*\* Such as congested office areas, lunchrooms, and locker rooms.

C. Guidelines for locating flammable gas systems when inside buildings (not B above) is as follows:

1. In an adequately ventilated area.
2. 6 meters (20 feet) from stored flammable materials or oxidizing gases.
3. Distance to open flames, ordinary electrical equipment or other sources of ignition, as determined by OHS Guide 4.12.0, Hazardous Locations.
4. 8 meters (25 feet) from areas normally occupied (offices, trailers, work spaces).
5. 15 meters (50 feet) from intakes of ventilation or air conditioning equipment and air compressors.
6. 15 meters (50 feet) from other flammable gas storage.
7. Protected against damage or injury due to falling objects or working activity in the area.
8. More than one system of 80 cubic meters (3,000 cubic feet) or less may be installed in the same

room, provided the systems are separated by at least 15 meters (50 feet). Each such system is to meet all of the requirements of this section.

### VIII. FACILITY DESIGN CONSIDERATIONS

#### A. *Outdoor Locations*

1. Where barrier walls or roofs are provided, they should be constructed of noncombustible materials. Where the enclosing sides adjoin each other, the area should be ventilated.
2. Electrical equipment within 4.5 meters (15 feet) is to be in accordance with Article 501 of the National Electrical Code for Class I, Division 2 locations.

#### B. *Separate Buildings*

Separate buildings should be built of at least noncombustible construction. Windows and doors should be located so as to be readily accessible in case of emergency. Windows should be of plastic in metal frames.

Electrical installation are to conform to Article 501 of the National Electrical Code for Class 1, Division 2 locations and OH&S Guide.

Heating, if provided, is to be by steam, hot water, or other approved indirect means.

#### C. *Special Rooms*

Floor, walls, and ceiling should have a fire-resistance rating of at least two hours. Walls or partitions should be continuous from floor to ceiling and are to be securely anchored. At least one wall is to be an exterior wall. Openings to other parts of the building should not be permitted, but if provided, should be equipped with Class B fire doors. Windows and doors should be in exterior walls and are to be located so as to be readily accessible in case of emergency. Windows should be of plastic in metal frames.

#### D. *Ventilation*

1. Adequate ventilation to the outdoors is to be provided. For lighter-than-air gases, natural ventilation is adequate with inlet openings located near the floor in exterior walls only; and outlet openings located at the high point of the room in exterior walls or roof. Inlet and outlet openings are to have a minimum total area of 0.09 sq. meter (one square foot) per 30 cubic meters (1,000 cubic feet) of room volume. For heavier-than-air gases, positive ventilation is necessary with inlet openings located above the flammable gas system and outlet openings located near the floor or other low points. Discharge from outlet openings is to be directed or conducted to a safe location.
2. Explosion venting is to be provided in exterior walls or roof only, in accordance with NFPA 68 "Guide for Explosion Venting."

#### E. *Fire Protection*

1. Flammable gas fires are not normally extinguished until the supply of gas has been shut off because of the danger of reignition or explosion. In the event of fire, large quantities of water may have to be sprayed on adjacent equipment to cool the equipment and prevent involvement in the fire. Sprinkler systems provide the most efficient application of water, and combination fog and solid stream hand nozzles permit widest adaptability in manual fire control. Small flammable gas fires have been extinguished by dry chemical extinguishers or with carbon dioxide, nitrogen and steam. Reignition may occur if a metal surface adjacent to the flame is not cooled with water or other means.
2. The various conditions under which flammable gas systems are used at BNL, including unattended installations, necessitates coordination between the user, facility manager, and the Safety and Environmental Protection Division for adequate and reliable fire protection of the system.
3. Personnel are to be cautioned that some flammable gas flames (such as hydrogen) are practically invisible and may only be detected by heat waves.

**IX. EXISTING SYSTEMS**

After consultation with the Safety and Environmental Protection Division, existing systems which are not in strict compliance with the provisions of this standard may continue in use when such continued use will not constitute an unreasonable hazard to life or adjoining property. Such systems shall be documented by the Department.